APPARATUS FOR VAPORIZATION OF LIQUID

BACKGROUND

Formation of deposits and clogging in flow channels can be challenges confronting almost any application involving vaporization of a liquid having a tendency to form solid deposits. One exemplary application is the vaporization of fuel oil such as might be performed prior to introducing the fuel into a combustion chamber. Vaporization of fuel oil is difficult because the temperature for complete vaporization is similar to the temperature at which breakdown of the fuel can occur. Introduction of an atomized spray into the combustion chamber, in which atomization can be achieved by using high fuel pressures or by atomization into compressed air, represents an exemplary alternative, but high pressure or compressed air systems are often undesirable due to the increased parasitic power cost, the equipment requirements, and/or the noise associated with providing the high fuel pressures or compressed air. In addition, atomization approaches are typically not suitable for applications where vaporization is needed such as applications where the fuel oil is not combusted. The problems associated with vaporization can become even more apparent when implemented in applications spanning wide operating ranges. Therefore, a need exists for apparatus capable of vaporizing liquids over wide operating ranges without forming deposits, clogging flow channels, or requiring high fuel line pressures or utilizing compressed air for atomization.

DESCRIPTION OF DRAWINGS

Embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. **1***a* is an illustration of the cross-section of an embodiment of a liquid vaporizer comprising threaded first and second bodies.

FIG. **1***b* is a detail view of the mated surfaces in one embodiment of a liquid vaporizer comprising threaded first and second bodies.

FIG. **2** is an illustration of the cross-section of an embodiment of a liquid vaporizer comprising non-threaded first and second bodies.

FIG. **3** is an illustration showing an embodiment of a liquid vaporizer comprising tapered first and second bodies having textured surfaces.

FIG. **4** is an illustration of an embodiment of a liquid vaporizer comprising tapered first and second bodies.

FIG. **5** is an illustration of an embodiment of a liquid vaporizer utilizing an electrical cartridge heater.

FIG. **6** is an illustration of the cross section of an embodiment of a liquid vaporizer utilizing a resistive element heater.

FIG. **7** is an illustration of an embodiment of a liquid fuel vaporizer and combustor.

DETAILED DESCRIPTION

At least some aspects of the present disclosure describe apparatus for vaporizing liquid in a vaporization pathway having an actively controlled temperature. In one embodiment, the liquid vaporizer comprises a first body having a cross sectional shape and dimensions substantially equal to the cross sectional shape and dimensions of a cavity in a second body, which allows the first body to be non-permanently inserted into the second body. The outer surface of the first body, the inner surface forming the cavity in the second body, or both can be modified to create a vaporization pathway between the first and second bodies when the surfaces mate and/or align. The liquid vaporizer can further comprise a vaporization pathway inlet for fluid comprising liquid, a vaporization pathway outlet for fluid comprising primarily vapor, and a heater in thermal communication with the first body, the second body, or both. The heater provides active control of the temperature of the vaporization pathway.

As used herein, the non-permanent insertion of the first body into the second body refers to the ability to non-destructively insert and separate the first body relative to the second body. The capability to separate the first and second bodies can, for example, facilitate cleaning and/or maintenance of the vaporization pathway and any assemblies or structures that may not be accessible but for removing the first body from the second body. The joining of the two bodies can form a substantially non-leaking union. Any variety of mechanisms can be used to secure the first body in the second body as necessary. Examples of fastening mechanisms can include, but are not limited to, screw threads, fastening tabs, compression fittings, friction fittings, locking jaws, locking studs, etc.

Modifications to the outer surface of the first body and/or the inner surface forming the cavity in the second body can result in a vaporization pathway comprising a channel formed along the outer surface of the first body, along the inner surface forming the cavity of the second body, or both, such that when the two bodies and/or surfaces mate, fluid can flow through the channel. In some embodiments, the channel is curved to increase the vaporization pathway length, which, in many instances, can increase the amount of time and/or distance for heat transfer.

In one embodiment, the temperature of the vaporization pathway is actively controlled through a heater providing electrical heat. Alternatively, the heater can comprise a heat exchanger. In various embodiments, the heater can be in thermal communication with the first body, the second body, and/or both to heat the vaporization pathway. Exemplary electrical heaters can include, but are not limited to, cartridge heaters, heating strips, and radiative heaters. Heat exchangers can utilize any variety of heat sources including, but not limited to, heat from a unit process upstream and/or downstream from the liquid vaporizer.

According to one particular embodiment, referring to FIGS. **1***a* and **1***b*, the first body **101** comprises a screw having screw threads **103**. The inner surface forming the cavity in the second body **102** comprises cavity threads **104** corresponding to the screw threads. The vaporization pathway comprises a channel **105** formed from modifications to the screw threads, the cavity threads, or both. In the context of threads, exemplary modifications can include, but are not limited to, truncating, notching, and/or removing at least a portion of the ribs composing the screw threads, the ribs composing the cavity threads, or both. Accordingly, the first body **101** can be screwed into the second body **102** and the modified threads can provide a vaporization pathway for fluid flow. Referring to FIG. **1***b*, which is a detail view of the embodiment illustrated in FIG. **1** *a*, the tips of the cavity threads **104** have been bored (i.e., truncated) to a larger inside diameter such that when the screw threads **103** are mated, a channel **105** is formed between the bored cavity threads **104** and the screw threads **103**.

In alternative embodiments, the vaporization pathway can comprise one or more channels formed in the outer surface of the first body, the inner surface forming the cavity in the second body, or both. In such embodiments, there may or may not be protruding studs, ribs, or other structures from either of the bodies. In the context of such alternative embodiments,